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Issues and Assumptions Relevant to Biomass Modeling

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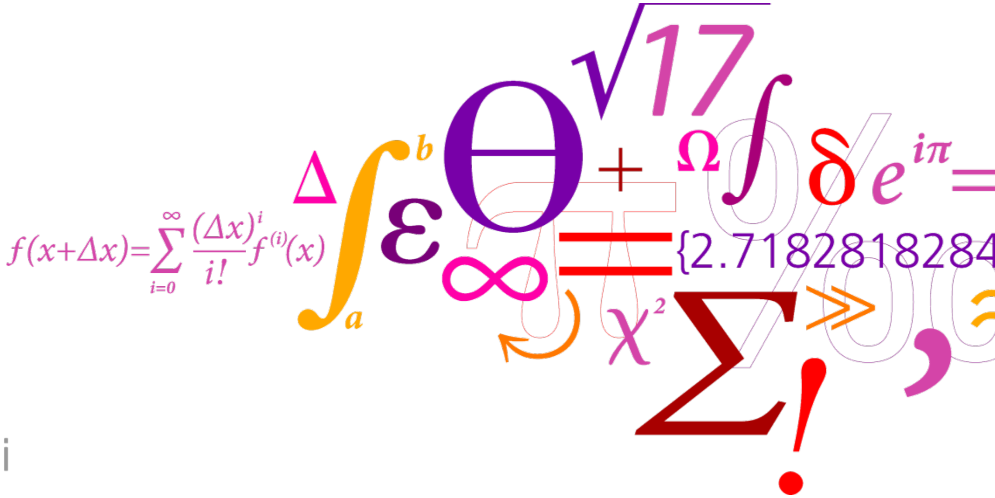

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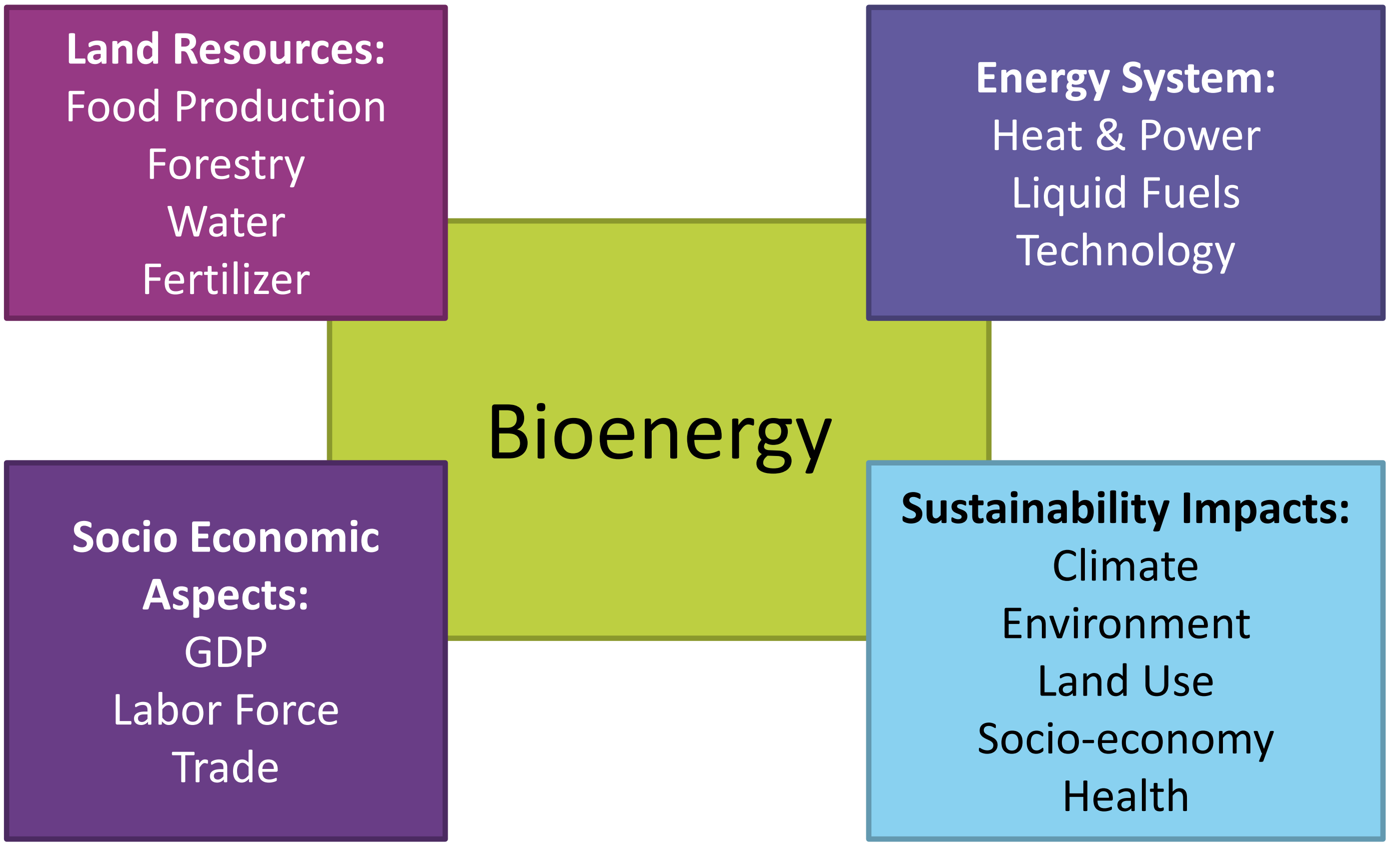
Importance of Biomass in a modeling framework



If bioenergy isn't considered, it gives an incomplete picture of the potential for other energy resources, technologies, climate and environmental impacts, and socio-economic and sustainability assessments.

Approaches to Modeling Biomass

- Top Down: Maximize economic value of land, Benefit-Cost, or long term utility under a given carbon constraint

Versus

- Bottom Up: Obtain detailed information on technologies, costs and options for a given piece of land and then determine the carbon prices at which the various options become economic

- Integrated: a dynamic land allocation system is built into the model and calculates land distribution and economic land use endogenously (IMAGE, GCAM)

Versus

- Soft Linked: Land distribution/ Land use scenarios/ Biomass production are derived exogenously and input into the IA model (Most IA models)

Bioenergy Potential

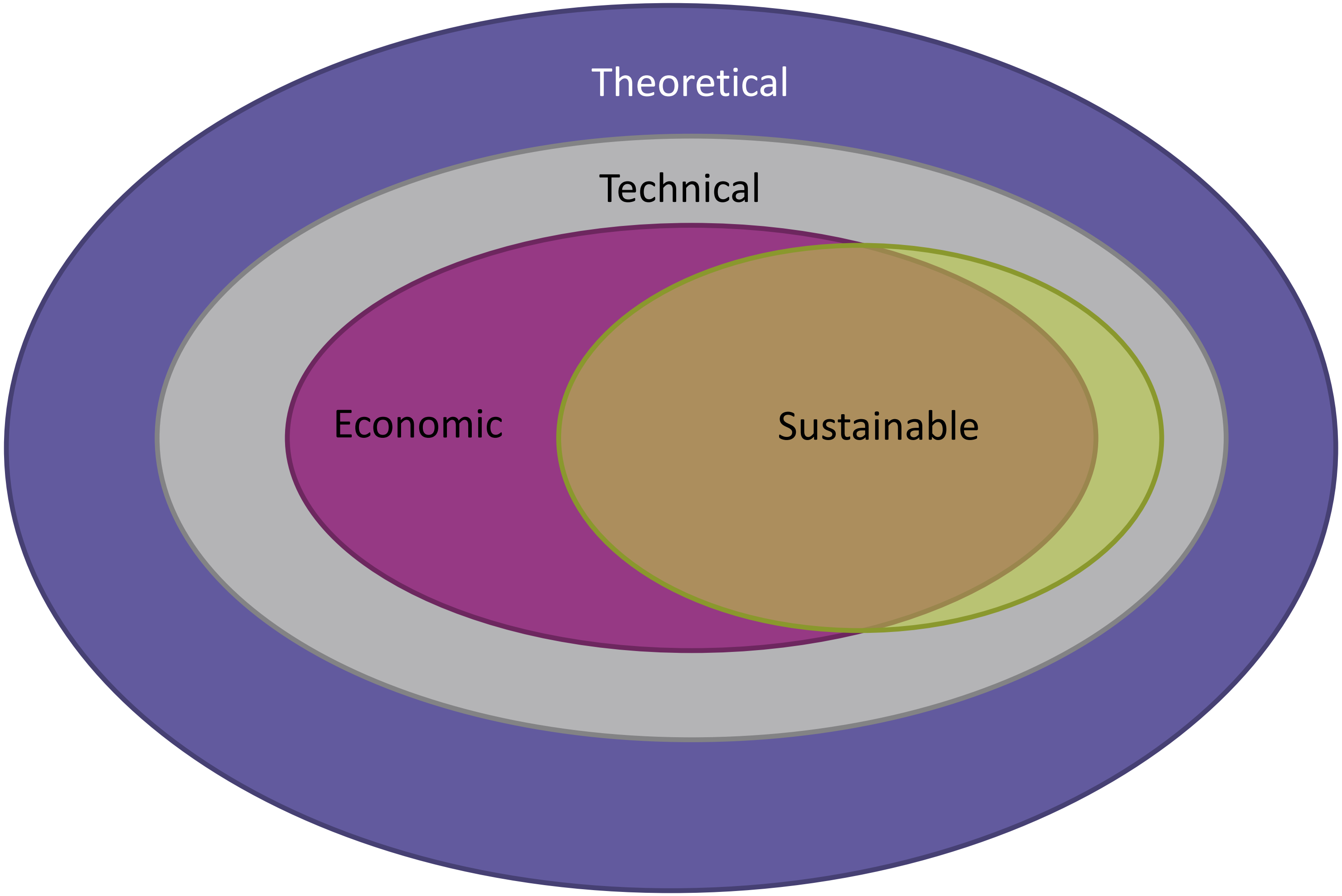
- Theoretical Potential – total amount that can theoretically produced from climate zone, soil, PET, etc.

- Technical Potential (Supply Potential) – often used interchangeably with theoretical, but here taken to mean the amount that can feasibly be produced given current land use and technology.

- Economic Potential (Demand Potential)– amount of biomass demanded by the global market in consideration of other energy options.

- Sustainable Potential – amount of biomass that can be produced given considerations for socioeconomic and environmental sustainability.

Bioenergy Potential

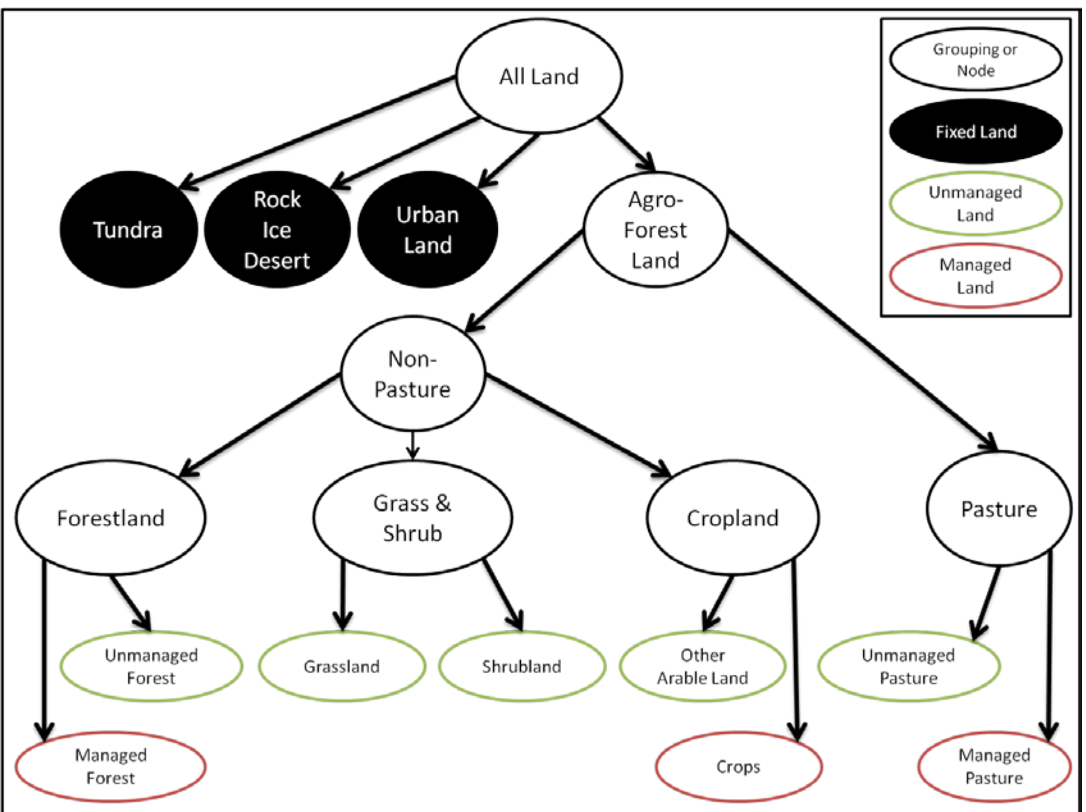


Considerations for Biomass Supply (Potential isn't everything!)

- ***Productivity and bioenergy***
  - Types of land availability
  - Yield assumptions
  - Technology
- ***Socioeconomics and bioenergy***
  - GDP growth assumptions
  - Future diets and meat consumption
  - Allocation of capital and labor between agriculture and industry
- ***Sustainability and bioenergy***
  - Protected lands
  - Forests
  - Biodiversity
  - Food security
  - Water
  - Socioeconomic sustainability and livelihood impacts
- ***International trade and bioenergy***
  - Full global trade in bio resources
  - Partial trade on sustainability/energy security requirements
  - Effect of trade on regional economies and environments

Example 1 Environmental Impact: Modeling Future Global Diet in GCAM

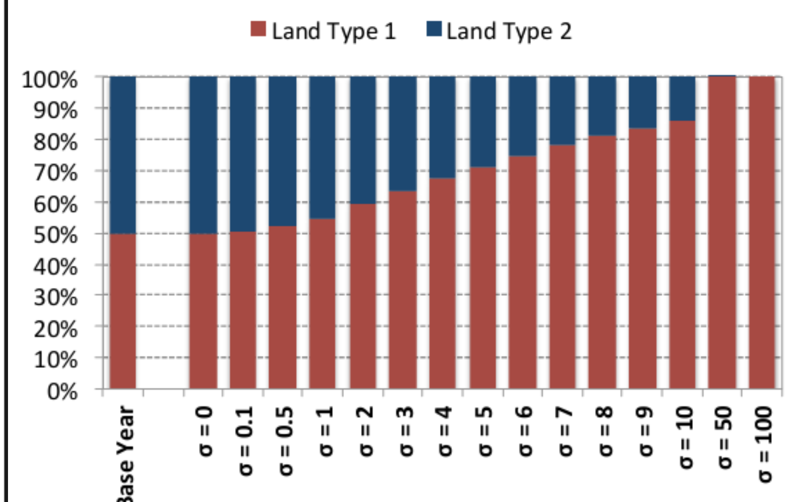
- GCAM: Global Change Assessment Model- endogenous land use model
- Changes based on land rent (equal marginal profit between potential uses), subject to share weight, and production cost
- Also includes collection and aggregation cost for residue biomass, carbon cost from land conversion



$$s_i = \frac{(\alpha_i \pi_i)^\sigma}{\sum_j (\alpha_j \pi_j)^\sigma}$$

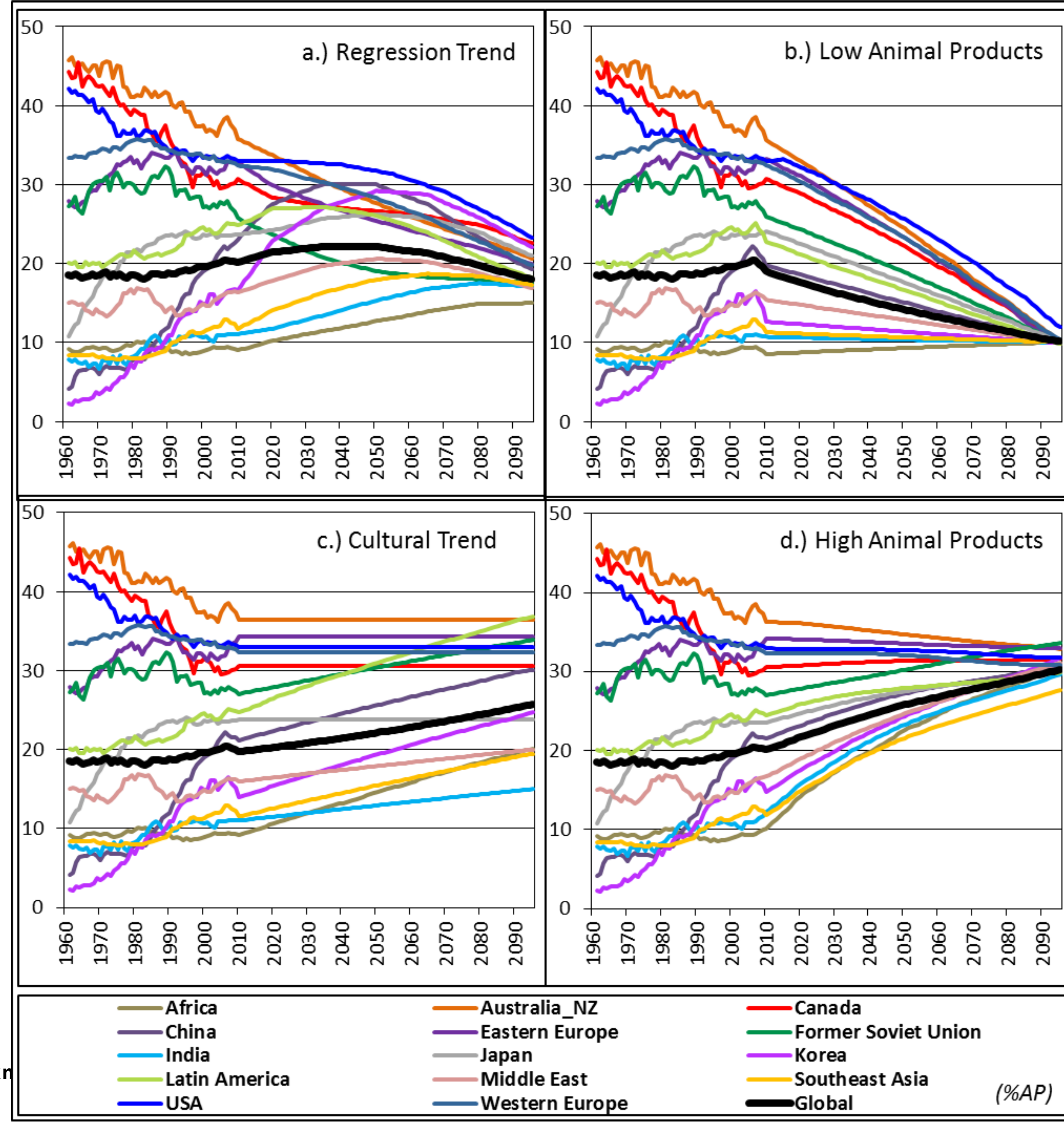
Source: Clarke and Edmonds (1993), McFadden (1974)

Change in land shares when land type 1's profit increases by 20%



Diet Scenarios

a) Meta-regression projection from historical FAO data
b) Diets converge to that of India & Africa
c) Diets in the developing world evolve to diets in the developed world
d) Diets evolve to western diet (US, Canada, Western EU, Australia/NZ)



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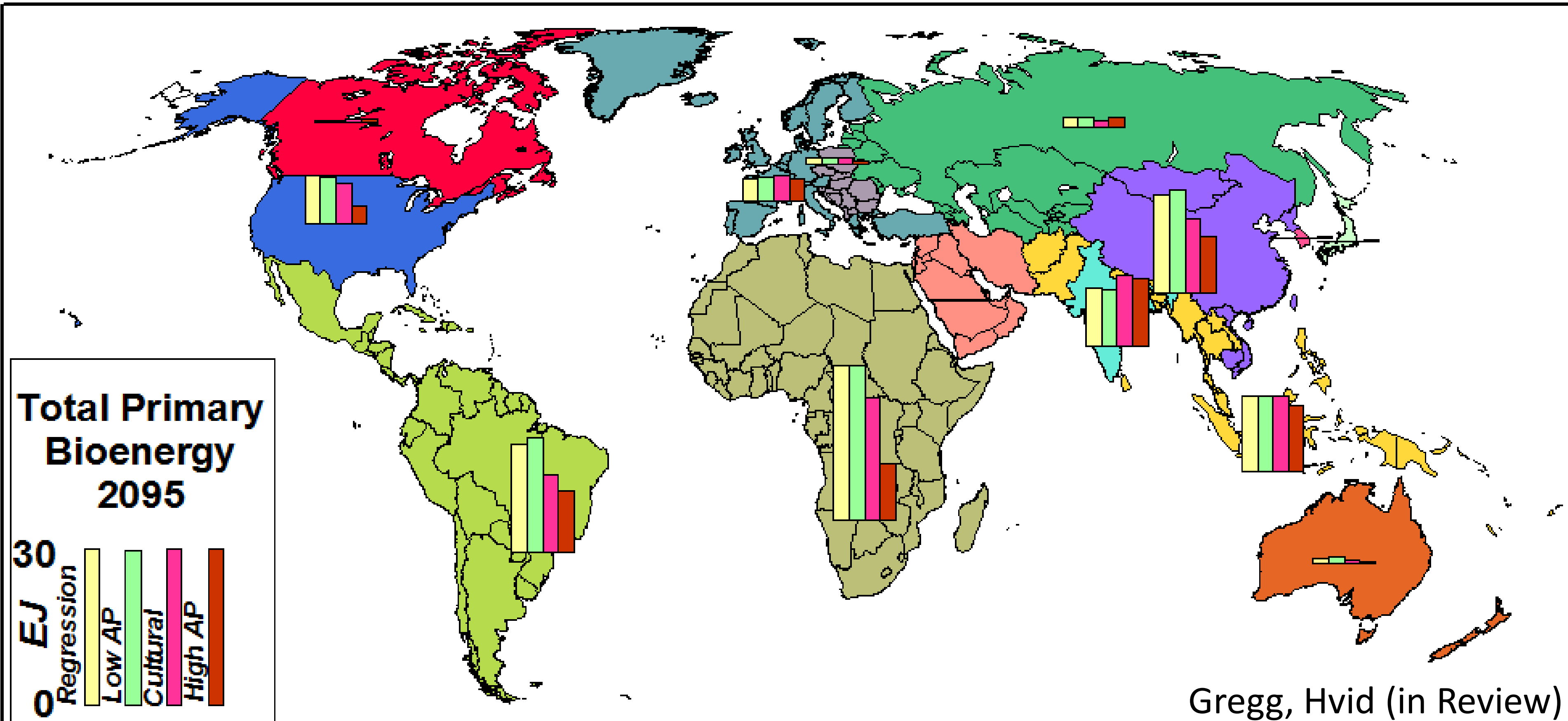
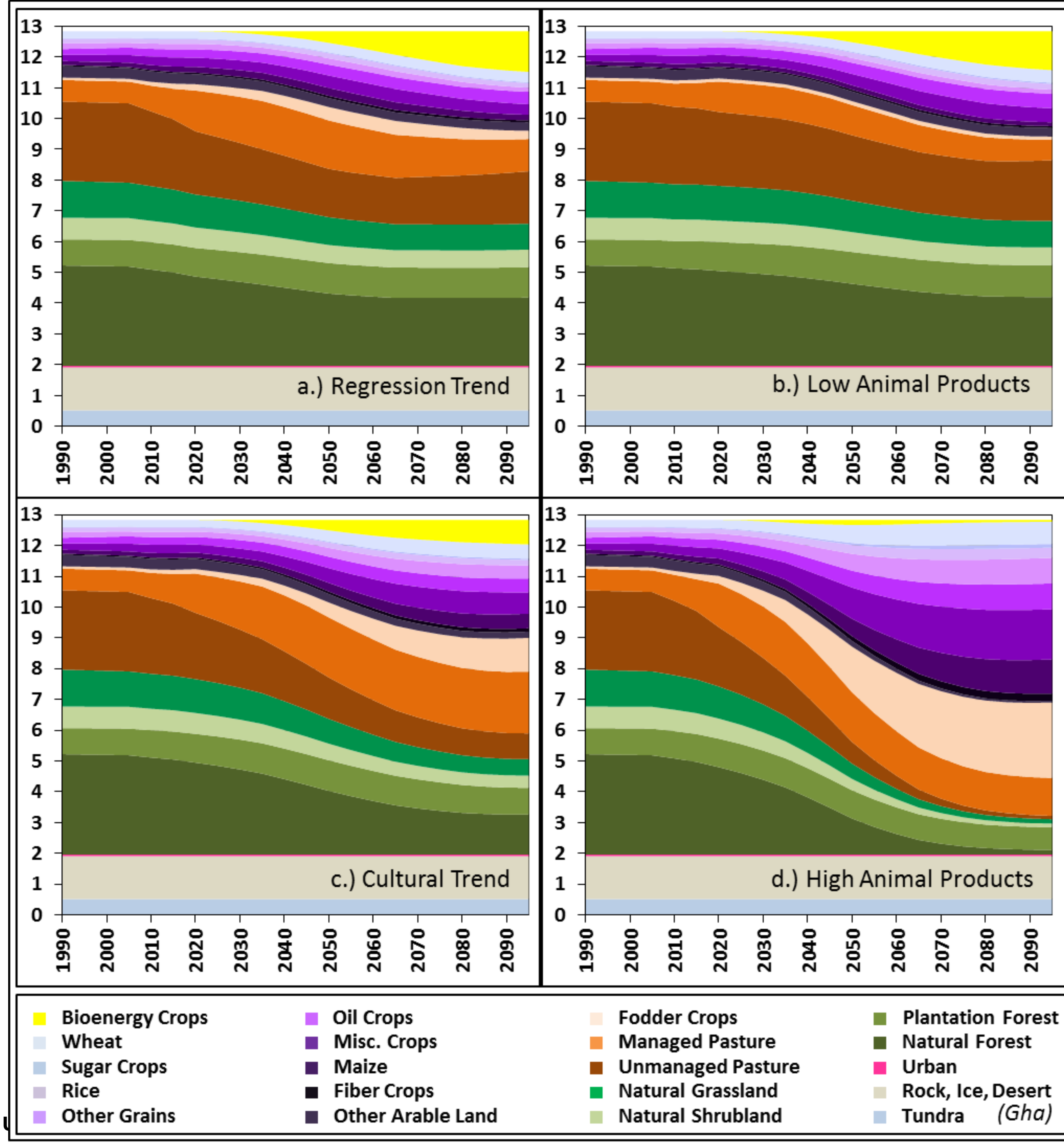
Economic Bioenergy Potential

- Potential decreases as meat consumption increases



Land Use Impact: Allocation

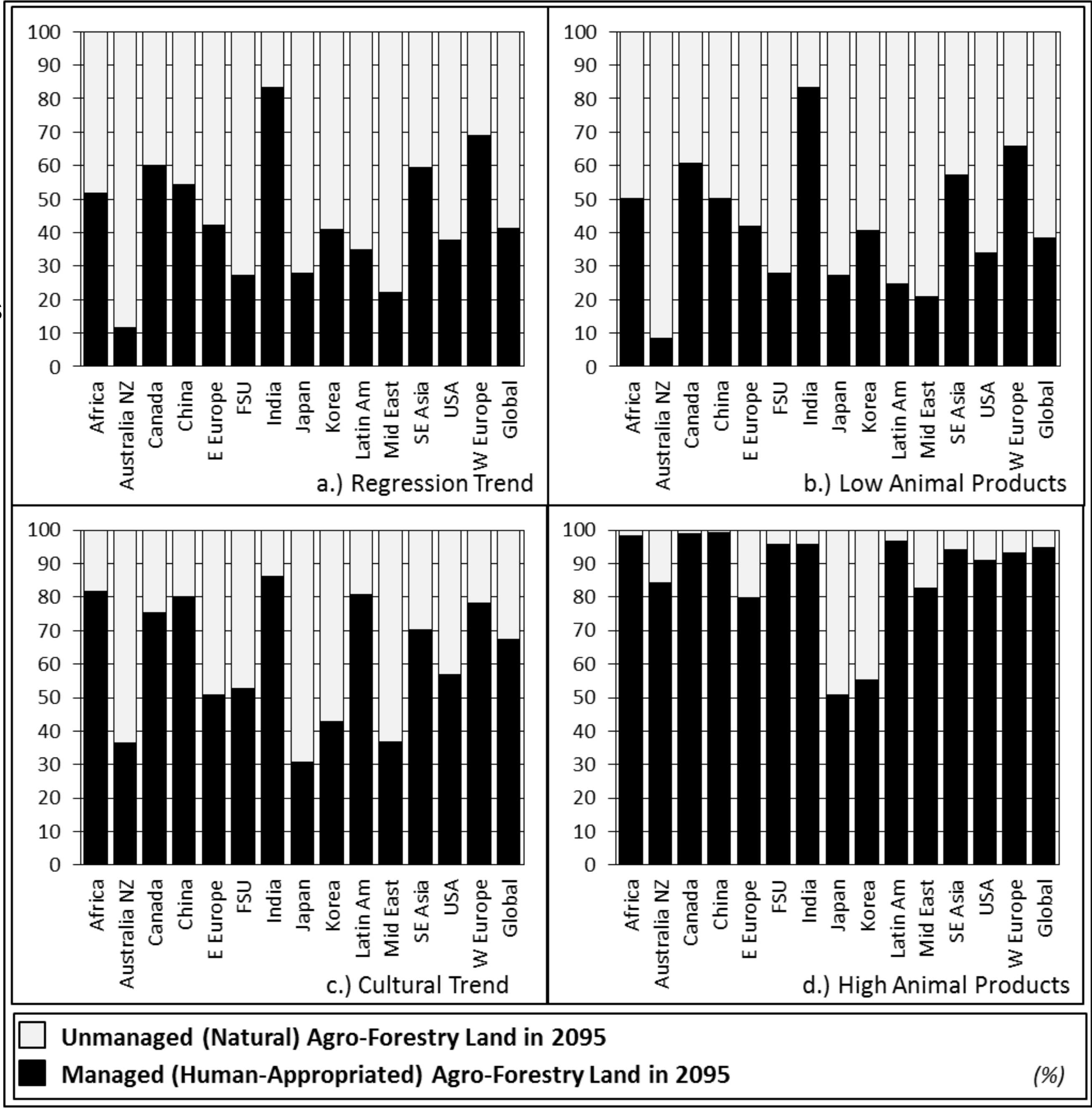
Substantial differences in land allocation



Gregg, Hvid (in Review)

Land Use Impact: Managed vs. Natural Land

Large differences in farm/plantation land across scenarios and regions.



Gregg, Hvid (in Review)

Example 2 Socioeconomic Sustainability

Integrating livelihood and equity outcomes into global assessments of bioenergy deployment

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Integrating place-specific livelihood and equity outcomes into global assessments of bioenergy deployment

OPEN ACCESS | FOCUS ON SECOND GENERATION BIOFUELS AND SUSTAINABILITY

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Show affiliations

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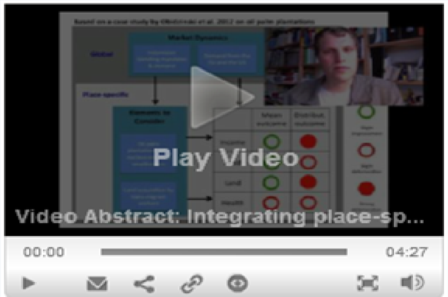
Abstract

Integrated assessment models suggest that the large-scale deployment of bioenergy could contribute to ambitious climate change mitigation efforts. However, such a shift would intensify the global competition for land, with possible consequences for 1.5 billion smallholder livelihoods that these models do not consider. Maintaining and enhancing robust livelihoods upon bioenergy deployment is an equally important sustainability goal that warrants greater attention. The social implications of biofuel production are complex, varied and place-specific, difficult to model, operationalize and quantify. However, a rapidly developing body of social science literature is advancing the understanding of these interactions. In this letter we link human geography research on the interaction between biofuel crops and livelihoods in developing countries to integrated assessments on biofuels. We review case-study research focused on first-generation biofuel crops to demonstrate that food, income, land and other assets such as health are key livelihood dimensions that can be impacted by such crops and we highlight how place-specific and global dynamics influence both aggregate and distributional outcomes across these livelihood dimensions. We argue that place-specific production models and land tenure regimes mediate livelihood outcomes, which are also in turn affected by global and regional markets and their resulting equilibrium dynamics. The place-specific perspective suggests that distributional consequences are a crucial complement to aggregate outcomes; this has not been given enough weight in comprehensive assessments to date. By narrowing the gap between place-specific case studies and



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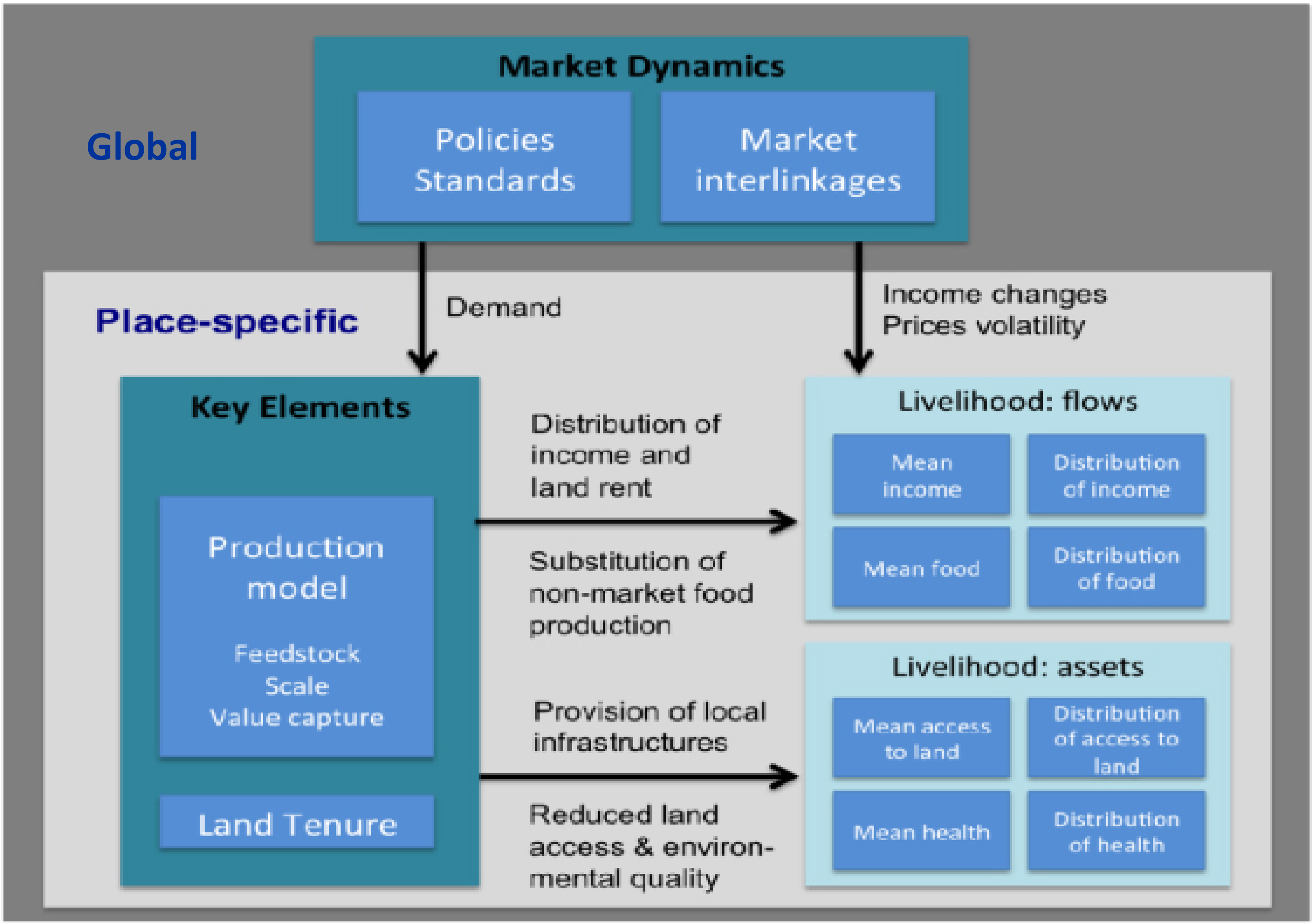
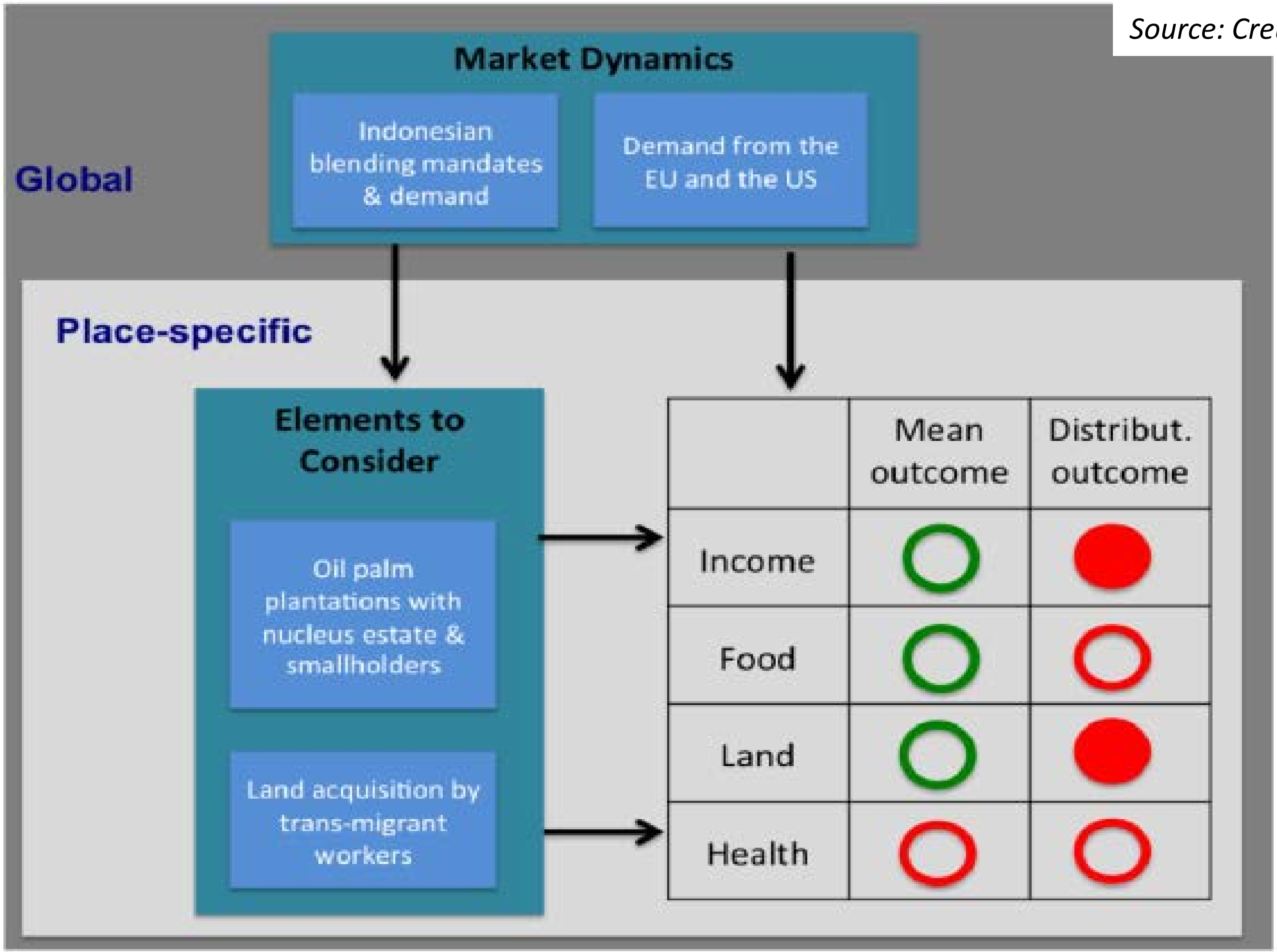
Biofuel deployment affects livelihoods via global and local processes



Source: Creutzig F., E. Corbera, S. Bolwig, and C. Hunsberger. (2013). Integrating place-specific livelihood and equity outcomes into global assessments of bioenergy deployment. Environmental Research Letters 8, 035047.

Assessment of livelihood outcomes for smallholder oil palm producers in Indonesia (Obidzinski et al 2012)

Source: Creutzig et al 2013



Possible livelihood outcomes from bioenergy deployment

Normal text: aspects considered by 'best' IAMs (Golub et al 2012)
Red text: Outcomes not considered by IAMs

Livelihood aspect	Benefits	Harms
Income and occupation	Higher total income Multiplier effects on wider economy	Lower purchasing power of non-farm poor Lower income of displaced people Exclusion of non-monetary occupations
Food	Higher security with higher income	Lower food access for non-farm poor Reduced food supply from subsistence farming
Land	Higher land rent for formal land owners	Lower access to land and ecosystem services, particularly for those without land titles
Other assets	New education, health and production infrastructure Higher savings	Detrimental health impacts Social conflicts Indebtedness

Source: Creutzig et al 2013

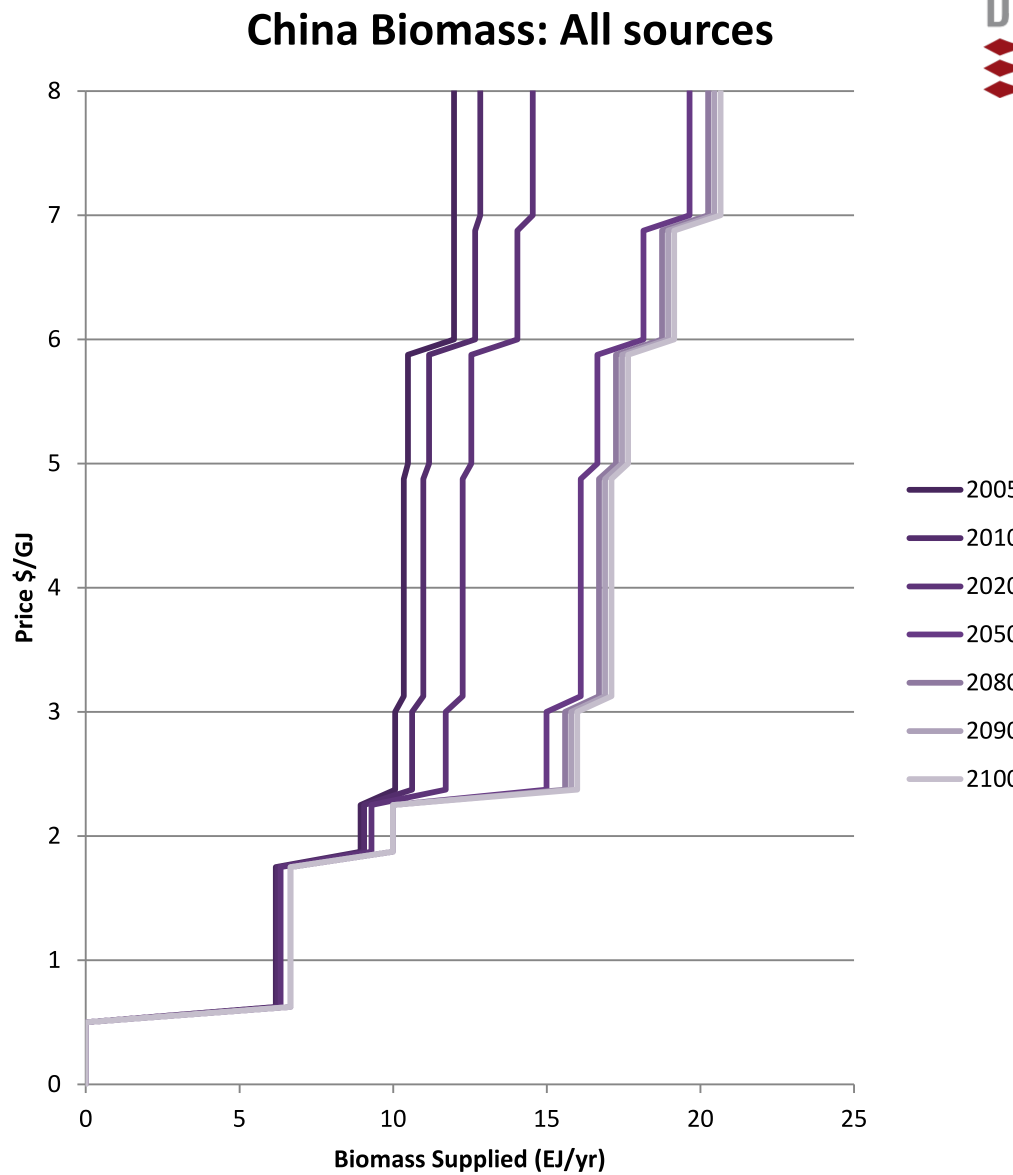
Conclusions

- **Summary:**
- **Place-specific factors** (production model, land tenure, initial land use), and **national contexts**, strongly influence livelihood effects of bioenergy deployment
- There is a likely **tension between aggregate and equity impacts** of bioenergy deployment that goes unnoticed by IAMs
- Bioenergy pathways and production models should not only produce positive aggregate outcomes, but also **respect and improve place-specific livelihoods**

- **Implications for global IAMs:**
- IAMs **do not consider**
  - **distribution** of costs and benefits at micro scale – e.g. by not considering livelihood assets
  - **factors** shaping the interaction between bioenergy and livelihoods – production model, land tenure, …
- IAMs **could be improved by**
  - introducing **distributional parameters** – e.g. %age of affected households with improved or reduced income, food access, land tenure and health as a result of deployment schemes
  - **Soft-coupling** IAMs with local livelihood analyses and CGE/sector models – e.g. ranking deployment scenarios in terms of their impact on livelihood dimensions (income, food, assets) based on **mapping of such impacts using livelihood assessment figures** such as Fig. 2.

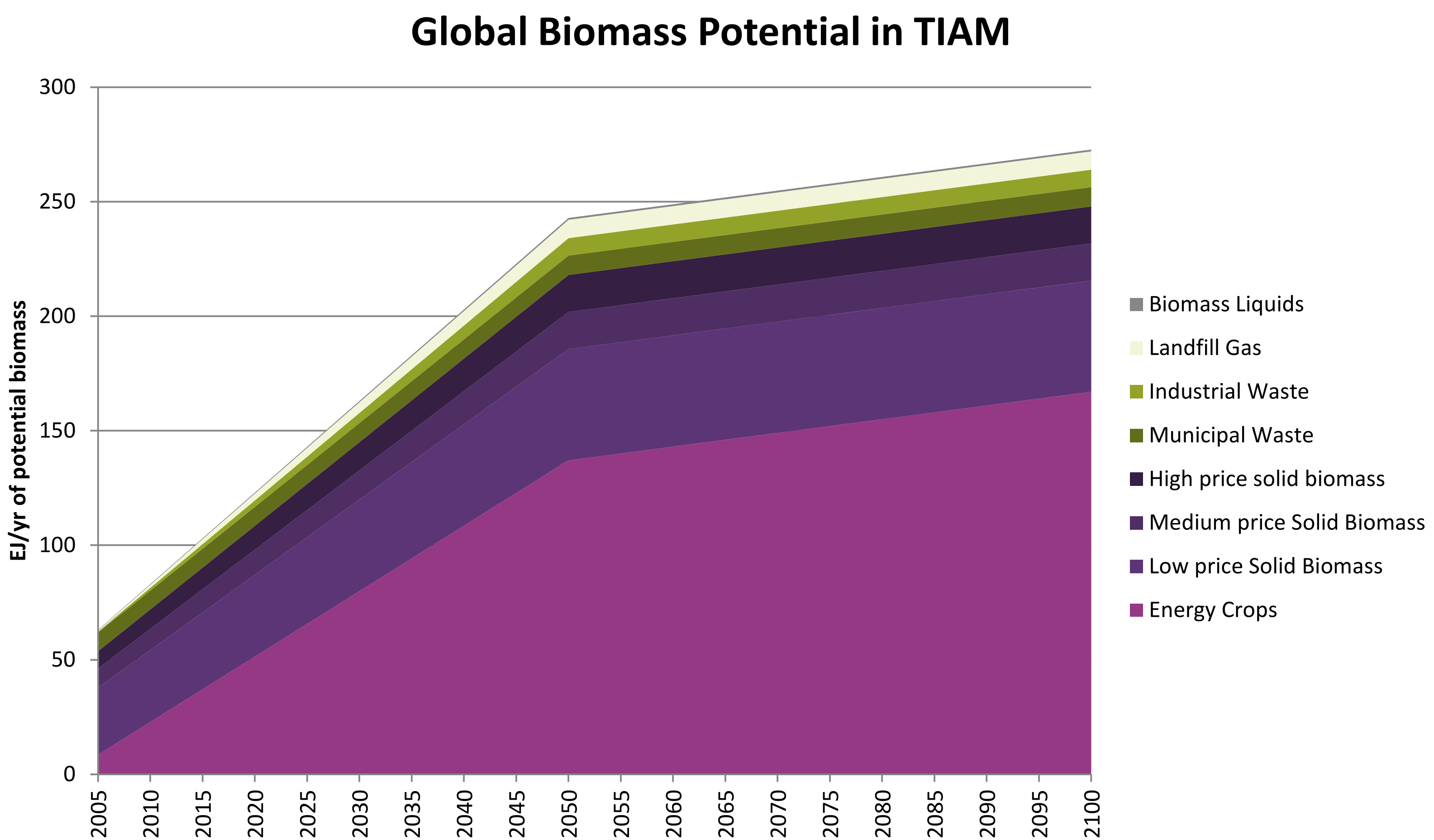
Biomass in TIAM

Biomass is treated as a fixed resource, similar to something mined or extracted. Thus the cost curve is the only “lever” available for creating different bioenergy assumptions and scenario.



*Technically, in TIAM, the price per unit energy remains constant (though it can be changed), and the supply varies through time.

Biomass in TIAM



Options for Development of TIAM wrt Bioenergy

1. Continue to use other models and meta-analyses to soft-link supply potentials into TIAM

2. Develop TIAM to handle land allocation and land use endogenously.
   - Better understanding of the potential for various feed stocks (i.e. crop choice)
   - Better understanding of the potential for various technologies (agricultural management, harvesting, aggregating, transporting, processing, and distributing)
   - Estimates of trade, and the geographical areas where changes would most likely occur.
   - Better understanding of the impacts (LUC, emissions, biodiversity, food prices) from bioenergy
   - More robust integrated model of the energy system